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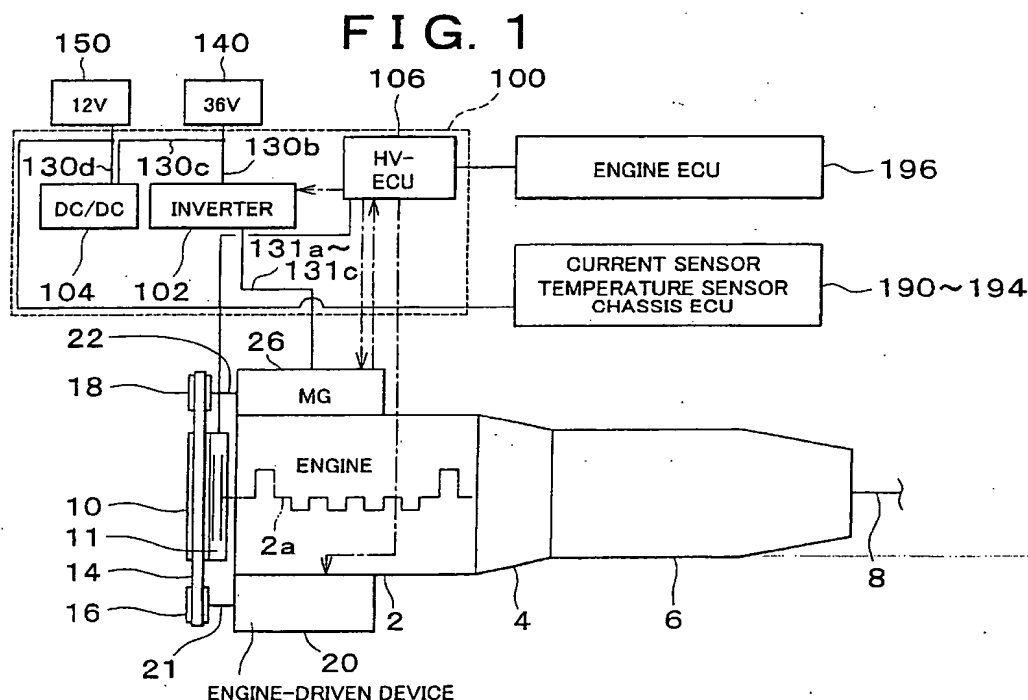
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(54) **Power control unit for a vehicle**

(57) A power control unit installed on a vehicle including a first power source (150) and a second power source (140) which have respective different voltages, an inverter (102) connected to a rotary device (26) and connected to at least one of the first and second power sources (150, 140). A converter (104) is connected to

the first and second power sources. A casing (110) is formed of an electrically conductive material and has a grounding terminal (112) formed thereon, wherein the inverter (102) and the converter (104) are accommodated within the casing (110), and are connected to the grounding terminal (112) through said casing



EP 1 266 801 A2

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Description**BACKGROUND OF THE INVENTION****1. Field of Invention**

[0001] The present invention relates to a vehicle having two power sources having respective different voltages, an inverter and a converter, and more particularly to a vehicle power control unit wherein the inverter and the converter are unitized.

2. Description of Related Art

[0002] In known electric and hybrid vehicles, two power sources having respective different voltages, an inverter and a converter are provided. In the electric and hybrid vehicles of this type, the inverter and the converter are usually integral to improve the ease of installation on the vehicle and servicing or other working operations.

[0003] In the known electric and hybrid vehicles, grounding wires for the inverter and converter are provided independently of each other, and are electrically connected to the vehicle body, for the inverter and converter to be separately earthed. This grounding arrangement tends to complicate a wiring system, with a relatively large number of components, undesirably causing an increase in the cost of manufacture of the power control unit and deterioration in the ease of servicing of the power control unit.

SUMMARY OF THE INVENTION

[0004] It is an object of the present invention to reduce an increase in the cost of manufacture and deterioration in the ease of servicing of a power unit of a vehicle which includes two power sources having respective different voltages, an inverter and a converter.

[0005] The object indicated above may be achieved according to one aspect of this invention, which provides a power control unit that is installed on a vehicle including (a) a first power source and (b) a second power source which have respective different voltages, (c) an inverter to be connected to a rotary device and at least one of the first and second power sources, and (d) a converter to be connected to the first and second power sources. The power control unit has a unit casing in which the inverter and the converter are accommodated. The unit casing is formed of an electrically conductive material and has a grounding terminal formed thereon. The inverter and the converter are connected to the grounding terminal through the unit casing.

[0006] In the vehicle power controlled unit constructed as described above, the inverter and the converter are connected to the common grounding terminal through the unit casing formed of the electrically conductive material. Accordingly, the inverter and converter need not be earthed to the vehicle body through respec-

tive separate grounding wires. This arrangement makes it possible to reduce the number of components and the cost of manufacture of the power control unit, simplify its wiring system, and improving the ease of servicing or other working operations on the power control unit.

[0007] According to a first preferred form of this invention, the grounding terminal is formed integrally with the unit casing.

[0008] The unit casing having the integrally formed grounding terminal is effective to reduce the number of the required components of the power control unit.

[0009] According to a second preferred form of this invention, the converter is located below the inverter within the unit casing.

[0010] According to a third preferred form of this invention, cooling means is provided between the inverter and the converter.

[0011] The inverter and the converter generate heat during operations and need to be cooled. This cooling can be achieved by the cooling means provided between the inverter and converter. Thus, the cooling structure is simplified.

[0012] According to a fourth preferred form of this invention, the grounding terminal is formed on an upper surface of the unit casing.

[0013] The grounding terminal formed on the upper surface of the unit casing permits easy servicing or other working operations on the power control unit.

[0014] According to a fifth preferred form of the present invention, the unit casing includes a first casing member having the grounding terminal, and a second casing member, and at least one of the inverter and the converter is connected to the second casing member and the first and second casings are fixed and electrically connection to each other.

[0015] In the fifth preferred form of the invention wherein the unit casing includes the first and second casing members as described above, the power control unit can be easily serviced, by disassembling the first and second casing members. Where the inverter and the converter are connected to the second casing member without the grounding terminal formed thereof, for some reason or other in designing the power control unit, the first casing member with the grounding terminal formed thereon and the second casing member can be fixed and electrically connected to each other, so that the inverter and the converter are electrically connected to the grounding terminal, assuring the intended functions of the inverter and converter.

[0016] According to one advantageous arrangement of the above fifth preferred form of the invention, the inverter is connected to the first casing member, while the converter is connected to the second casing member.

[0017] According to another advantageous arrangement of the above fifth preferred form of the invention, the first and second casing members are electrically connected to each other through a bus bar fixed to the outer surfaces of the first and second casing members.

[0018] In the above arrangement, the first and second casing members are electrically connected to each other through the bus bar fixed to their outer surfaces. Thus, the electrical connection of the first and second casing members can be easily achieved by a simple arrangement. Where a sealing member made of a resin material is provided for water-proof purpose or fluid tightness at the conjunction between the first and second casing members, the first and second casing members can be electrically connected to each other by the bus bar, so that the inverter and converter can be connected to the grounding terminal, assuring the intended functions of the inverter and converter.

[0019] According to a further advantageous arrangement of the above fifth preferred form of this invention, each of the first and second casing members has a sealing portion and a metallic contactor portion at a junction between the first and second casing members.

[0020] The above arrangement wherein the sealing portion and the metallic contactor portion are provided at the junction between the first and second casing members permits electrical continuity between the two casing members without using any exclusive members such as a bus bar, while securing fluid tightness between the two casing members.

[0021] According to a sixth preferred form of the present invention, coil windings of the rotary device and the inverter are connected to each other through power wires, and terminal portions to which the power wires are connected are disposed on an upper surface of the unit casing.

[0022] In the above arrangement wherein the terminal portions are disposed on the upper surface of the unit casing, the terminal portions and the power wires can be easily connected to each other.

[0023] In the above arrangement, it is desirable that the terminal portions project from the upper surface of the unit casing, and then extends laterally of the unit casing.

[0024] In the above desired arrangement wherein the terminal portions project upwards from the upper surface of the unit casing, the ease of connection of the terminal portions to the power wires is further improved. In addition, the terminal portions extending laterally of the unit casing prevents a large vertical distance between the upper surface of the unit casing and the corresponding end portions of the power wires connected to the terminal portions, so that the structure including and located around the terminal portions can be made relatively compact, while permitting easy electrical connection between the terminal portions and the power wires.

[0025] In the desired arrangement described just above, it is preferable that the unit casing consists of a main body portion and an upper casing portion which is removably fixed to the main body portion in a direction perpendicular to the upper surface, and the upper casing portion includes an upper wall having an open-

ing which permits the terminal portions to pass there-through when the upper casing portion is fixed and removed to and from the main body portion.

[0026] In the preferable arrangement described just above, the upper casing portion can be removed from the main body portion in the direction perpendicular to the upper surface, facilitating the servicing or maintenance of the power control unit. When the upper casing portion is fixed and removed to and from the main body portion, the terminal portions can pass through the opening. Thus, the fixing and removal of the upper casing portion can be made without an interference with the terminal portions.

[0027] In the arrangement described just above, it is further preferable to provide a terminal support plate disposed on the upper surface of the upper casing portion such that the terminal support plate normally supports the terminal portions and extends across the opening, the terminal support plate being slidably movable on the upper surface of the upper casing portion laterally of the upper casing portion.

[0028] In the further preferable arrangement described above, the terminal support plate supports the terminal portions. When the upper casing portion is removed from the main body portion, the terminal support portion is slidably moved on the upper surface of the upper casing portion away from the opening such that the terminal portions remain on the upper surface of the upper casing portion. When the upper casing portion is fixed to the main body portion, the terminal support plate is slidably moved such that the terminal portions are supported by the terminal support plate disposed on the upper surface of the upper casing portion. Accordingly, the upper casing portion can be easily fixed and removed to and from the main body portion.

[0029] In the above arrangement, the terminal support plate may be dimensioned to be able to close the opening.

[0030] The terminal support plate closing the opening prevents entry of foreign matters or water into the unit casing.

[0031] The rotary device indicated above may be a three-phase rotary device such as a three-phase AC motor/generator. In this case, the terminal portions indicated above may include terminal portions corresponding to respective coil windings of three phases of the three-phase rotary device.

[0032] The unit casing may be provided with a covering member fixed thereto. This covering member includes a portion which extends over and covers the terminal portions, and has a projection and a recess for positioning the covering member relative to the unit casing. The covering member 126 is prevented from being erroneously oriented with respect to the unit casing, owing to the provision of the projection and the recess.

[0033] According to a seventh preferred form of the present invention, the unit casing is to be installed within an engine room of the vehicle.

[0034] In one advantageous arrangement of the seventh preferred form of the invention, the unit casing is dimensioned such that the unit casing can be disposed on a battery tray located in the engine room.

[0035] In the above advantageous arrangement, it is possible to minimize a required change of design of the engine room of the vehicle having the two electric power sources, with respect to the engine room of a vehicle having a single electric power source.

[0036] In the advantageous arrangement described just above, the first power source may be a DC power source having a nominal voltage of 12V, while the second power source may be a DC power source having a nominal voltage higher than 12V. In this case, the unit casing may have a positive terminal of the first power source fixed thereto.

[0037] Conventional vehicles generally have a DC power source having a nominal voltage of 12V, that is, a 12V DC battery which is disposed in a battery tray located within an engine room of the vehicle. If the unit casing of the power control unit were disposed in the battery tray, the worker or vehicle driver would be puzzled when the engine of the present vehicle is started with a jumper cable connected to the 12V DC battery provided on another vehicle.

[0038] In view of the above drawback, the positive terminal of the 12V DC battery is desirably fixed to the unit casing, so that the worker can find the positive terminal without difficulty, when the engine of the present vehicle is started with the 12V DC battery provided on another vehicle.

[0039] According to an eighth preferred form of this invention, that connectors to be respectively connected to a plurality of components installed on the vehicle are accommodated within a one-piece casing fixed to the unit casing.

[0040] In the above eighth preferred form of the invention wherein the connectors for connecting the various components of the vehicle to the power control unit are accommodated within the one-piece casing, the power control unit can be made compact and can be easily serviced.

[0041] In the above eighth preferred form of the invention, the one-piece casing is preferably removably fixed to the unit casing.

[0042] In the above arrangement wherein the one-piece casing is removably fixed to the unit case, the ease of servicing of the power control unit is further improved.

[0043] The operating voltages of the plurality of components are different and the connectors to be connected to the components having the same operating voltage are preferably accommodated within said one-piece casing.

[0044] In the above arrangement, the ease of servicing of the power control unit is further improved since the connectors accommodated within the one-piece casing are to be connected to the components having

the same operating voltage.

[0045] According to another aspect of the present invention, there is provided a power control unit for a vehicle, which is electrically connected to a first power source having a nominal voltage of 12V and a second power source having a nominal voltage of 36V, said power control unit having a unit casing in which an inverter and a converter are accommodated. A first electric wire connecting each of at least one of the inverter and the converter to the first power source, and a second electric wire connecting at least one of the inverter and the converter to the second power source have respective outer coatings having respective different colors is provided. The outer coating of the second wire can have a yellow color, e.g., a bright yellow color.

[0046] In the power control unit according to the second aspect of this invention, the outer coatings of the first and second electric wires are differently colored, for easy distinction between those first and second wires, such that the ease of servicing of the power control unit is improved.

[0047] Usually, an electric wire having an orange-colored outer coating is used to indicate that an exposure to the voltage of the electric wire is seriously harmful to the human body. On the other hand, an exposure to the voltage of the second electric wire connected to the second power source having the comparatively high nominal voltage is not as seriously harmful to the human body, but is still hazardous to the human body. Thus, the outer coating of the second electric wire is bright-yellow colored, to clearly inform the worker that the exposure to the voltage of the second electric wire is not as seriously harmful to the human body but is still hazardous to the human body.

BRIEF DESCRIPTION OF THE DRAWINGS

[0048] The above and other objects, features, advantages, technical and industrial significance of this invention will be better understood by reading the following detailed description of an exemplary embodiment of the invention, when considered in connection with the accompanying drawings, in which:

Fig. 1 is a schematic system view of an automotive vehicle including a power control unit 100 according to one embodiment of this invention;

Fig. 2 is a view illustrating various components installed on the vehicle of Fig. 1;

Fig. 3 is an elevational view in vertical cross section of the power control unit 100 on the vehicle;

Fig. 4 is a plan view of the power control unit 100 with its cover 126 being removed;

Fig. 5 is a plan view of the power control unit 100 with the cover 126 installed thereon;

Fig. 6 is a perspective view of the cover 126; and

Fig. 7 is a cross sectional view taken along line 7-7 of Fig. 6.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0049] In the following description and the accompanying drawings, one exemplary embodiment of the present invention will be described in more detail.

[0050] Figs. 1 and 2 illustrate a schematic system view of an automotive vehicle comprising an engine 2 an output of which is transmitted to drive wheels 9 through a torque converter 4, an automatic transmission 6 and an output shaft 8. The output of the engine 2 is also transmitted to a belt 14 via a damper pulley 10 which is connected to a crankshaft 2a and incorporates an electromagnetic clutch 11. The belt 14 connects the damper pulley 10 to two pulleys 16, 18, for rotating these pulleys 16, 18. The electromagnetic clutch 11 incorporated within the damper pulley 10 is selectively placed in its engaged and released states, as needed, to connect and disconnect the pulley 10 to and from the crankshaft 2a.

[0051] The pulley 16 is connected to a rotary shaft 21 of an engine-driven device 20, so that the engine-driven device 20 is operated by a rotary drive force transmitted through the belt 14. The engine-driven device 20 may comprise at least one of a compressor for an air conditioning system, a power steering pump, and an engine cooling water pump, for instance.

[0052] The pulley 18 is connected to a rotary shaft 22 of a motor/generator 26 (hereinafter abbreviated as "MG"), which is one form of a rotary device. The MG 26 functions as an electric generator, as needed, so that a rotary drive force received from the engine 2 through the pulley 18, or from the vehicle drive wheels 9, is converted into an electric energy by the MG 26. The MG 26 also functions as an electric motor, as needed, to rotate one or both of the crankshaft 2a and the rotary shaft 21 of the engine-driven device 20, through the rotating shaft 22, pulley 18 and the belt 14. The MG 26 is a three-phase AC motor/generator.

[0053] The vehicle has a power control unit 100, which includes an inverter 102, a DC/DC converter 104, and an electronic hybrid control unit 106 (hereinafter abbreviated as "HV-ECU"). The inverter 102 and the MG 26 are electrically connected to each other through power wires 131a, 131b and 131c, while the inverter 102 and a second power source in the form of a high-voltage DC power source 140 (e.g., having a nominal voltage of 36V) are electrically connected to each other through a power wire 130b. The DC/DC converter 104 is electrically connected to the inverter 102 and the high-voltage DC power source 140 through a power wire 130c, and further to a first power source in the form of a low-voltage power source 150 (e.g., having a nominal voltage of 12V) through a power wire 130d. The outer coatings of the power wires 131a, 131b, 131c, 130b and 130c are a bright yellow color, while that of the power wire 130d is a black color.

[0054] When the MG 26 functions as the electric gen-

erator, the inverter 102 under the control of the HV-ECU 106 performs a switching action for controlling the voltage and amount of energy generated by the MG 26, to charge the high-voltage DC power source 140 with the electric energy generated by the MG 26. At the same time, the charging of the low-voltage DC power source 150 is also effected through the DC/DC converter 104.

[0055] While the MG 26 is not generating an electric energy, the electric power is supplied from the high-voltage DC power source 140 to the low-voltage DC power source 150, since these two power sources 140, 150 are electrically connected to each other.

[0056] When the MG 26 functions as the electric motor, the inverter 102 under the control of the HV-ECU 106 permits the electric power to be supplied from the high-voltage DC power source 140 to the MG 26.

[0057] The HV-ECU 106 is arranged to effect automatic engine stopping and starting controls, as well to control the inverter 102. That is, the HV-ECU 106 automatically turns off the engine 2 when a predetermined engine-stopping condition is satisfied, and automatically starts the engine 2 when a predetermined engine-starting condition is satisfied. To effect the automatic engine starting control, the HV-ECU 106 places the electromagnetic clutch 11 incorporated in the pulley 10, in its engaged state, and controls the inverter 102 so as to supply the electric power from the high-voltage DC power source 140 to the MG 26 as described above, for driving the MG 26 to crank the engine 2. In the automatic engine stopping control, the HV-ECU 106 holds the electromagnetic clutch 11 in its released state, and control the inverter 102 so as to supply the electric power from the high-voltage DC power source 140 to the MG 26 as described above, for driving the MG 26 to operate the engine-driven device 20.

[0058] Fig. 2 describes an exemplary arrangement of the various components installed on the vehicle.

[0059] The power control unit 100 has a unit casing 110. The power control unit 100 is disposed in a part of an engine room 40 which is relatively near a passenger or occupant compartment 42. The unit casing 110 is dimensioned such that the unit casing 110 can be mounted on a battery tray (not shown) which is similar to that used to install a DC 12V power source used on a known vehicle which uses only the 12V power source device as its electric power source device. The unit casing 110 is mounted on this battery tray in the present vehicle.

[0060] On the other hand, the high-voltage DC power source 140 and the low-voltage DC power source 150 are installed in a rear part of the vehicle.

[0061] The construction of the power control unit 100 will be described in detail, by reference to Figs. 3-7. Fig. 3 is an elevational view in vertical cross section of the power control unit 100 according to the present embodiment. Fig. 4 is a plan view of the power control unit 100 with its cover 126 being removed. Fig. 5 is a plan view of the power control unit 110 with its cover 126 being installed thereon. Fig. 6 is a perspective view of the cov-

er 126, while Fig. 7 is a cross sectional view taken along line 7-7 of Fig. 6.

[0062] The unit casing 110 consists of an upper casing portion 110a and a lower main body portion 110b, which are formed of a metallic electrically conductive material. The upper casing portion 110a is removably fixed to the main body portion 110b such that the upper casing portion 110a extends upright from the main body portion 110b. The upper casing portion 110a and the main body portion 110b are electrically connected to each other by a metallic bus bar 118, which is connected at its one end to the outer surface of the upper casing portion 110a and at the other end to the outer surface of the main body portion 110b. On the upper surface of the upper casing portion 110a, a common grounding terminal 112 is formed integrally with the upper casing portion 110a.

[0063] Within the unit casing 110, the DC/DC converter 104 is disposed under the inverter 102. The inverter 102 has a negative terminal connected to the upper casing portion 110a through a contactor 114a, while the DC/DC converter 104 has a negative terminal connected to the main body portion 110b through a contactor 114b. As described above, the upper casing portion 110a having the integrally formed grounding terminal 112 and the main body portion 110b are electrically connected to each other, so that the inverter 102 and the DC/DC converter 104 are electrically connected to the common grounding terminal 112 through the unit casing 110. The common grounding terminal 112 is connected through a suitable conductor (not shown) to the body of the vehicle, so that the inverter 102 and the converter 104 are earthed.

[0064] Each of three substantially L-shaped bus bars 160a, 160b and 160c (corresponding to U, V and W phases, respectively) is connected at its one end to the inverter 102, and the other end portion of each bus bar 160a, 160b, 160c passes through an opening 120 formed through the top wall of the upper casing portion 110a, and extends laterally of the unit casing 110 towards the front of the vehicle, so as to function as a terminal portion 162a, 162b, 162c (corresponding to the U, V and W phases, respectively). To the terminal portions 162a, 162b and 162c, there are connected the respective power wires 131a, 131b and 131c corresponding to the U, V and W phases of a stator coil (not shown) of the MG 26, so that the inverter 102 is connected to the MG 26.

[0065] The opening 120 formed through the top wall of the upper casing portion 110a has an area of opening larger than a sum of surface areas of the terminal portions 162a, 162b, 162c as viewed in the vertical direction, so that the terminal portions 162a, 162b, 162c can pass through the opening 120 when the upper casing portion 110a is removed from the main body portion 110b.

[0066] The terminal portions 162a, 162b, 162c are supported by a terminal support plate 122, which is dis-

posed on the upper surface of the upper casing portion 110a such that the terminal support plate 122 is slidably movable on the upper surface of the upper casing portion 110a and closes the opening 120.

[0067] To the upper casing portion 110a, there is fixed a cover 126 which includes a horizontally extending portion that extends over and covers the terminal portions 162a, 162b, 162c. As shown in Figs. 6 and 7, the cover 126 has a projection 127, and a recess 128 for engagement with a protrusion formed on the upper casing portion 110a. These projection 127 and recess 128 prevent erroneous positioning of the cover 126 relative to the upper casing portion 110a.

[0068] As shown in Fig. 5, a positive terminal 152 for the low-voltage DC power source 150 is fixed to the upper surface of the upper casing portion 110a, such that the positive terminal 152 is covered by a terminal cover 154. To inform the worker that the positive terminal 152 is for the low-voltage DC power source 150 having the nominal voltage of 12V, the upper surface of the terminal cover 154 is provided with an indication "+12V".

[0069] Between the inverter 102 and the DC/DC converter 104, there is provided cooling means in the form of a cooling water passage 180 communicating with an inlet pipe 180a and an outlet pipe 180b, so that cooling water introduced through the inlet pipe 180a flows through the cooling water passage 180 and is discharged through the outlet pipe 180b.

[0070] The power control unit 100 is provided with connectors 170a, 170b, 170c and 170d for connection with various components installed on the vehicle, such as a current sensor 190, a temperature sensor 192, a chassis ECU 194 and an engine ECU 196 (shown in Fig. 1). Since the current sensor 190, temperature sensor 192 and chassis ECU 194 have the same operating voltage of 12V, the corresponding connectors 170a-170c are accommodated within a one-piece casing 172. This one-piece casing 172 is removably attached to the upper surface of the upper casing portion 110a. A harness 174 which connects the interior of the power control unit 100 and the one-piece casing 172 extends through one of side walls of the main body portion 110b, as indicated in Fig. 4, and a portion of the harness 174 is located within the power control unit 100.

[0071] A connector 170e is provided to connect a field magnet circuit within the power control unit 100 and coil windings wound on the rotor of the MG 26. The outer coating of a power wire 133 connected to the connector 170e has a bright yellow (or golden yellow) color.

[0072] The upper casing portion 110a functions as a first casing member while the main body portion 110b functions as a second casing member.

[0073] The present embodiment of the invention described above has the following advantages:

- (1) Both, the inverter 102 and the converter 104 are connected to the common grounding terminal 112 through the unit casing 110 formed of the electrically

conductive material. Accordingly, the inverter 102 and converter 104 need not be earthed to the vehicle body through respective separate grounding wires. This arrangement makes it possible to reduce the number of components and the cost of manufacture of the power control unit 100, simplify its wiring system, and improve the ease of servicing or other working operations on the power control unit 100.

(2) While the inverter 102 and converter 104 generate heat during operations and need to be cooled, this cooling can be achieved by the cooling water passage 180 provided between the inverter 102 and converter 104. Thus, the cooling structure is simplified.

(3) The grounding terminal 112 formed on the upper surface of the unit casing 110 permits easy servicing or other working operations on the power control unit 100.

(4) The terminal portions 162a-162c disposed on the upper surface of the unit casing 110 permit easy operation to connect the terminal portions 162a-162c and the power wires 131a-131c.

(5) Since the terminal portions 162a-162c slightly project upwards from the upper surface of the unit casing 110, the ease of connection of the terminal portions 162a-162c to the power wires 131a-131c is further improved. In addition, the terminal portions 162a-162c extending laterally of the unit casing 110 prevents a large vertical distance between the upper surface of the unit casing 100 and the corresponding end portions of the power wires 131a-131c connected to the terminal portions 162a-162c, so that the structure including and located around the terminal portions 162a-162c can be made relatively compact, while permitting easy electrical connection between the terminal portions 162a-162c and the power wires 131a-131c.

(6) The unit casing 110 consists of the upper casing portion 110a and the main body portion 110b. The upper casing portion 110a can be removed from the main body portion 110b in the vertical direction, facilitating the servicing or maintenance of the power control unit 100. When the upper casing portion 110a is fixed and removed to and from the main body portion 110b, the terminal support plate 122 supporting the terminal portions 162a-162c is slidably moved on the upper surface of the upper casing portion 110a from the original position in which the opening 120 is closed by the terminal support plate 122, to a position in which the opening 120 is open so that the terminal portions 162a-162c can pass through the opening 120 when the upper casing portion 110a is fixed and removed. Thus, the fixing and removal of the upper casing portion 110a can be made without an interference with the terminal portions 162a-162c. When the upper casing portion 110a is attached to the main body portion

110b, the terminal support plate 122 is slidably moved on the upper surface of the upper casing portion 110a, laterally of the unit casing 110, so that after the attachment of the upper casing portion 110a, the terminal portions 162a-162c are supported on the terminal support plate 122 while the opening 120 is closed by the terminal support plate 122, to prevent entry of foreign matters or water into the unit casing 100 through the opening 120. Thus, a simple movement of the terminal support plate 122 makes it possible to support the terminal portions 162a-162c and close the opening 120.

(7) The connectors 170a-170c for connecting the various components of the vehicle to the power control unit 100 are accommodated within the one-piece casing 172, so that the power control unit 100 can be made compact and can be easily serviced. Further, the one-piece casing 172 is removable from the unit casing 110 so that the upper casing portion 110a can be easily removed. The ease of servicing of the power control unit 100 is further improved since the connectors 170a-170c accommodated within the one-piece casing 172 are to be connected to the components having the same operating voltage.

(8) The cover 126 is prevented from being erroneously oriented with respect to the upper casing portion 110a because the projection 127 and the recess 128 are engaged with the protrusion formed on the upper casing portion 110a.

(9) The unit casing 110 is dimensioned so that the unit casing 110 can be mounted on the battery tray provided in a laterally end portion of the engine room of the vehicle. This arrangement is effective to minimize a required change of design of the engine room of the present vehicle having the two electric power sources, with respect to the engine room of a vehicle having a single electric power source.

(10) The positive terminal 152 of the low-voltage DC power source 150 (having the nominal voltage of 12V) is fixed to the unit casing 110, so that when the engine of the present vehicle is started with a jumper cable connecting the positive terminal 152 to a 12V DC battery on another vehicle, the worker can find the positive terminal 152 without difficulty.

(11) The outer coatings of the power wires in the nominal 12V power source system and those in the nominal 36V power source system are differently colored, for easy distinction between those power wires in the two systems, such that the ease of servicing of the power control unit 100 is improved. The outer coatings of the power wires 131a-131c, 130b, 130c and 133 used in the nominal 36V power source system have a bright yellow (or golden yellow) color to clearly identify to the worker that an exposure to the voltage of those power wires is not seriously harmful to the human body, but is more or

less hazardous to the human body.

[0074] In the exemplary embodiment described above, the upper casing portion 110a and the main body portion 110b are electrically connected to each other through the bus bar 118. However, the exemplary embodiment can be modified in the following manner. The bus bar 118 may be replaced by metallic contactor portions provided at the junction between the upper casing and main body portions 110a, 110b, which portions are arranged to directly contact each other. In this case, the junction may consist of the metallic contactor portion and a sealing portion arranged to secure fluid tightness between the upper casing and main body portions 110a, 110b. This arrangement permits electrical continuity between the upper casing and main body portions 110a, 110b, without using any exclusive members such as, e.g., the bus bar indicated above.

[0075] In the illustrated embodiment, the controller (the HV-ECU 106) is implemented as a programmed general purpose electronic control unit. It will be appreciated by those skilled in the art that the controller can be implemented using a single special purpose integrated circuit (e.g., ASIC) having a main or central processor section for overall, system-level control, and separate sections dedicated to performing various different specific computations, functions and other processes under control of the central processor section. The controller can be a plurality of separate dedicated or programmable integrated or other electronic circuits or devices (e.g., hardwired electronic or logic circuits such as discrete element circuits, or programmable logic devices such as PLDs, PLAs, PALs or the like). The controller can be implemented using a suitably programmed general purpose computer, e.g., a microprocessor, microcontroller or other processor device (CPU or MPU), either alone or in conjunction with one or more peripheral (e.g., integrated circuit) data and signal processing devices. In general, any device or assembly of devices on which a finite state machine capable of implementing the procedures described herein can be used as the controller. A distributed processing architecture can be used for maximum data/signal processing capability and speed.

[0076] While the invention has been described with reference to preferred embodiments thereof, it is to be understood that the invention is not limited to the preferred embodiment or constructions. To the contrary, the invention is intended to cover various modifications and equivalent arrangements. In addition, while the various elements of the preferred embodiment are shown in various combinations and configurations, which are exemplary, other combinations and configurations, including more, less or only a single element, are also within the spirit and scope of the invention.

[0077] A power control unit installed on a vehicle including a first power source (150) and a second power source (140) which have respective different voltages, an inverter (102) connected to a rotary device (26) and

connected to at least one of the first and second power sources (150, 140). A converter (104) is connected to the first and second power sources. A casing (110) is formed of an electrically conductive material and has a grounding terminal (112) formed thereon, wherein the inverter (102) and the converter (104) are accommodated within the casing (110), and are connected to the grounding terminal (112) through said casing.

Claims

1. A power control unit (100) that is installed on a vehicle including (a) a first power source (150) and (b) a second power source (140) which have respective different voltages, (c) an inverter (102) to be connected to a rotary device and at least one of said first and second power sources, and (d) a converter (104) to be connected to said first and second power sources, said power control unit having a unit casing (110) in which said inverter and said converter are accommodated, **characterized in that:**

said unit casing (110) is formed of an electrically conductive material and has a grounding terminal (112) formed thereon, and said inverter (102) and said converter (104) are connected to said grounding terminal (112) through said unit casing (110).

2. A power control unit according to claim 1, **characterized in that** said grounding terminal (112) is formed integrally with said unit casing (110).
3. A power control unit according to claim 1, **characterized in that** said converter (104) is located below said inverter (102) within said unit casing (110).
4. A power control unit according to any one of claims 1-3, **characterized in that** a cooling device (180) is provided between said inverter (102) and said converter (104).
5. A power control unit according to any one of claims 1-4, **characterized in that** said grounding terminal (112) is formed on an upper surface of said unit casing (110).
6. A power control unit according to any one of claims 1-5, **characterized in that** said unit casing (110) comprises a first casing member (110a) having said grounding terminal (112) and a second casing member (110b), and at least one of said inverter and said converter is connected to said second casing member and said first and second casings are fixed and electrically connected to each other.
7. A power control unit according to claim 6, **characterized in that**

terized in that said inverter (102) is connected to said first casing member (110a), and said converter (104) is connected to said second casing member (110b).

8. A power control unit according to claim 6 or 7, **characterized in that** said first and second casing members (110a, 110b) are electrically connected to each other through a bus bar (118) fixed to outer surfaces of said first and second casing members.

9. A power control unit according to claim 6, wherein each of said first and second casing members (110a, 110b) has a sealing portion and a metallic contactor portion at a junction between the first and second casing members.

10. A power control unit according to any one of claims 1-9, **characterized in that** windings of said rotary device (26) and said inverter (102) are connected to each other through power wires (131a-131c), and terminal portions (162a-162c) to which said power wires (131a-131c) are connected are disposed on an upper surface of said unit casing (110).

11. A power control unit according to claim 10, **characterized in that** said terminal portions (162a-162c) project from said upper surface of said unit casing (110), and then extend laterally of said unit casing (110).

12. A power control unit according to claim 11, **characterized in that** said unit casing (110) includes a main body portion (110b) and an upper casing portion (110a) which is removably fixed to said main body portion in a direction perpendicular to said upper surface, and said upper casing portion (110a) includes an upper wall having an opening (120) which permits said terminal portions (162a-162c) to pass therethrough when said upper casing portion is fixed and removed to and from said main body portion.

13. A power control unit according to claim 12, **characterized in that** a terminal support plate (122) is disposed on the upper surface of said upper casing portion (110a) such that said terminal support plate normally supports said terminal portions (162a-162c) and extends across said opening (120), said terminal support plate being slidably movable on the upper surface of said upper casing portion (110a) laterally of said upper casing portion.

14. A power control unit according to claim 13, **characterized in that** said terminal support plate (122) is dimensioned to close said opening (120).

15. A power control unit according to any one of claims

10-14, **characterized in that** said rotary device (26) is a three-phase AC motor/generator, and said terminal portions (162a-162c) comprise terminal portions corresponding to respective coil windings of three phases of said motor/generator.

16. A power control unit according to any one of claims 10-15, **characterized by** further comprising a cover member (126) fixed to said unit casing (110), said cover member including a portion which extends over and covers said terminal portions (162a-162c), said cover member having a projection (127) and a recess (128) for positioning said cover member relative to said unit casing (110).

17. A power control unit according to any one of claims 1-16, **characterized in that** said unit casing (110) is installed within an engine compartment (40) of the vehicle.

18. A power control unit according to claim 17, **characterized in that** said unit casing (110) is dimensioned such that said casing can be disposed on a battery tray located in said engine compartment (40).

19. A power control unit according to claim 18, **characterized in that** said first power source (150) is a DC power source having a nominal voltage of 12V, and said second power source (140) is a DC power source having a nominal voltage higher than 12V, and said unit casing (110) has a positive terminal (152) of said first power source fixed thereto.

20. A power control unit according to claim 17, **characterized in that** said unit casing (110) is disposed in a portion of an engine compartment (40) of the vehicle, which is near a passenger compartment of the vehicle.

21. A power control unit according to any one of claims 1-20, **characterized in that** connectors (170a-170c) to be respectively connected to a plurality of components (190-194) installed on the vehicle are accommodated within said one-piece casing (172).

22. A power control unit according to claim 21, **characterized in that** said one-piece casing (172) is removably fixed to said unit casing (110).

23. A power control unit according to claim 21 or 22, **characterized in that** the operating voltages of said plurality of components (190-194) are different and said connectors to be connected to said components having the same operating voltage are accommodated within said one-piece casing (172).

24. A power control unit (100) for a vehicle, which is

electrically connected to a first power source (150) having a nominal voltage of 12V and a second power source (140) having a nominal voltage of 36V, said power control unit having a unit casing (110) in which an inverter (102) and a converter (104) are accommodated, **characterized in that:** 5

a first electric wire (130d) connecting at least one of said inverter (102) and said converter (104) to said first power source (150), and a 10
second electric wire (130b, 130c) connecting at least one of said inverter and said converter to said second power source (140) have respective outer coatings having respective different 15
colors, the outer coating of said second electric wire is a yellow color.

25. A power control unit according to claim 24, **characterized in that** the outer coating of the second electric wire is a bright yellow color. 20

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FIG. 1

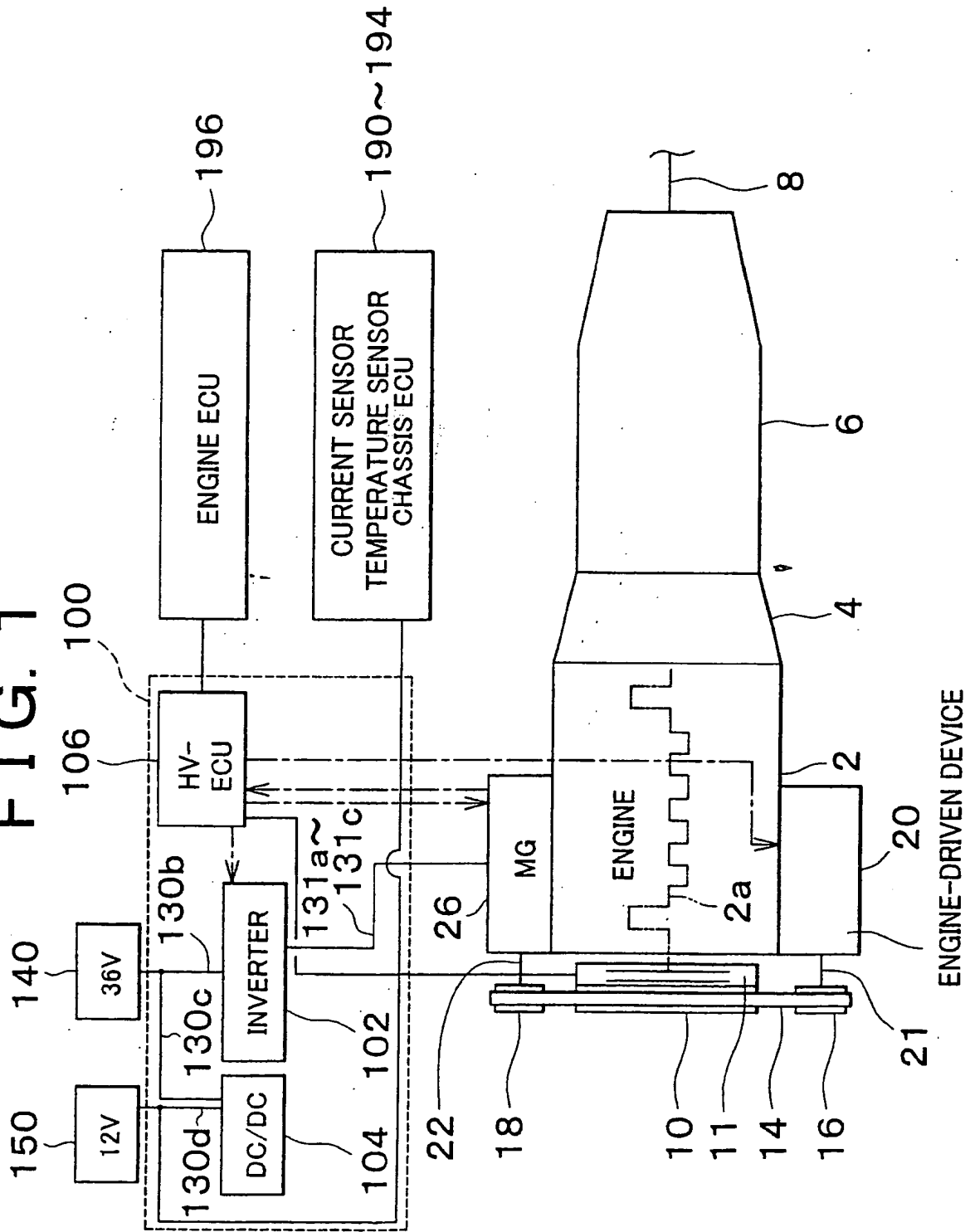


FIG. 2

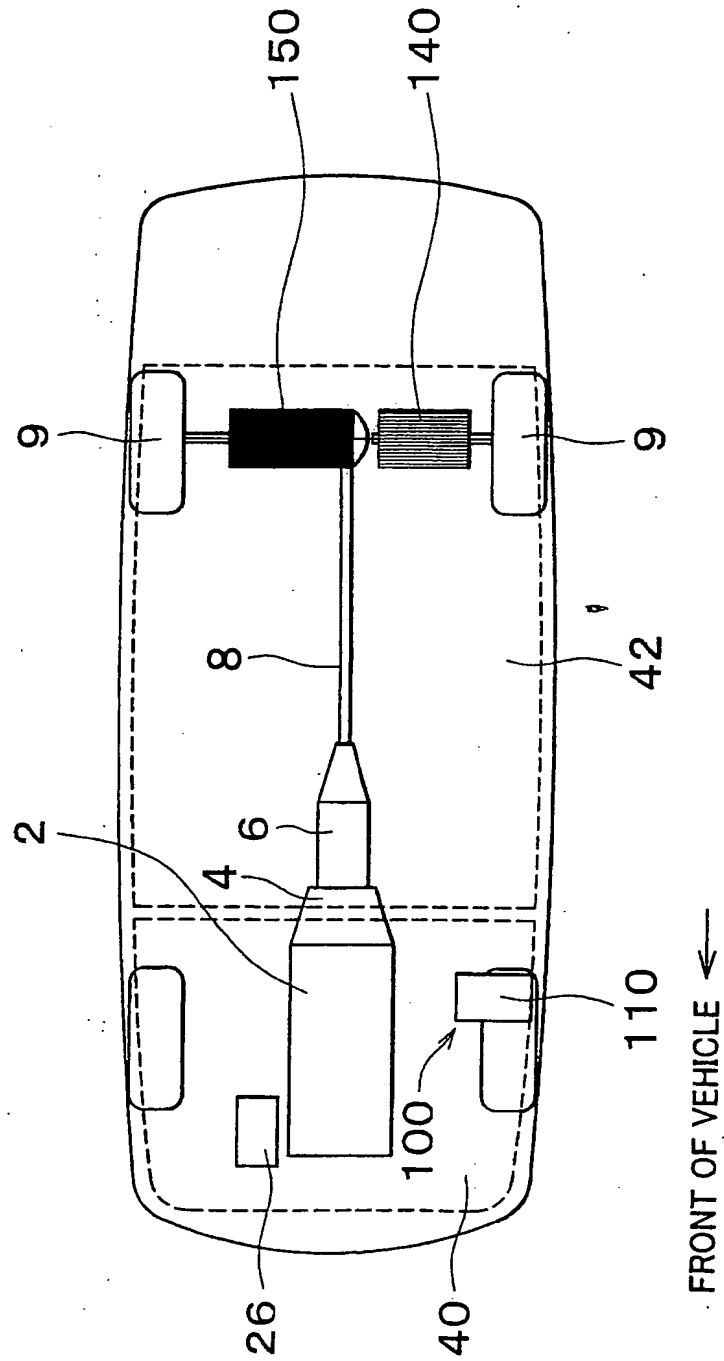


FIG. 3

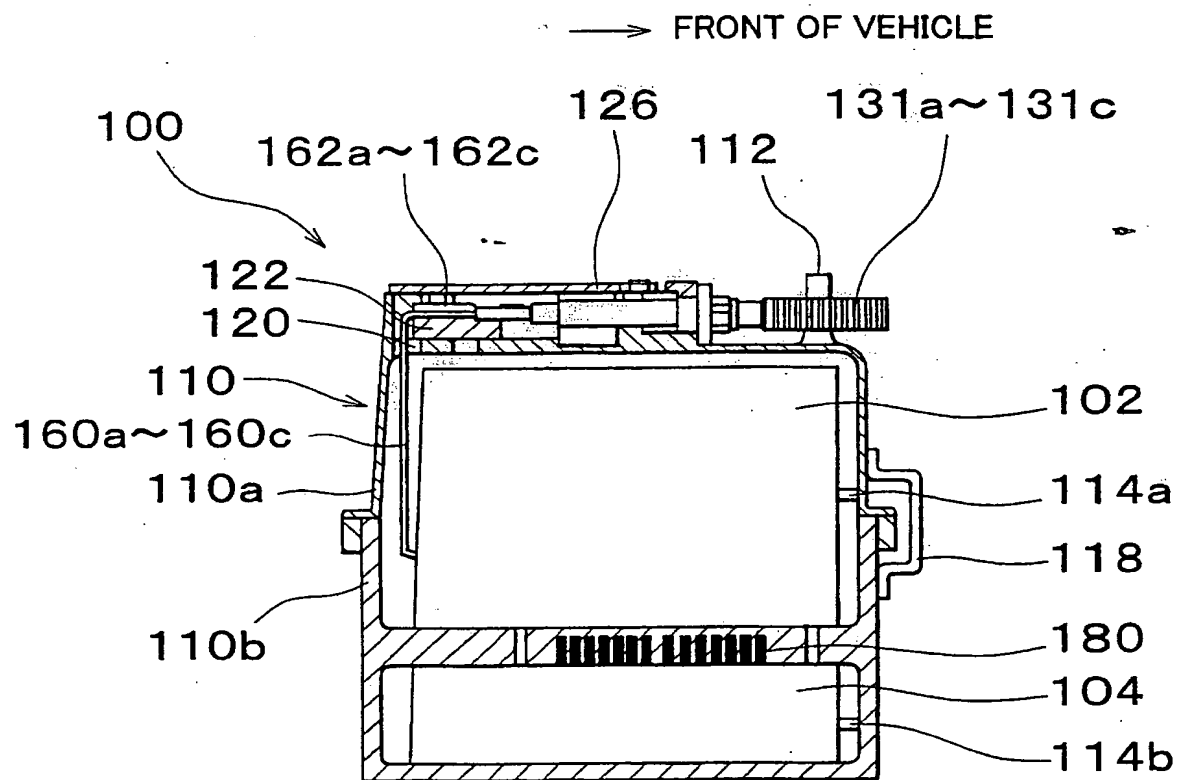


FIG. 4

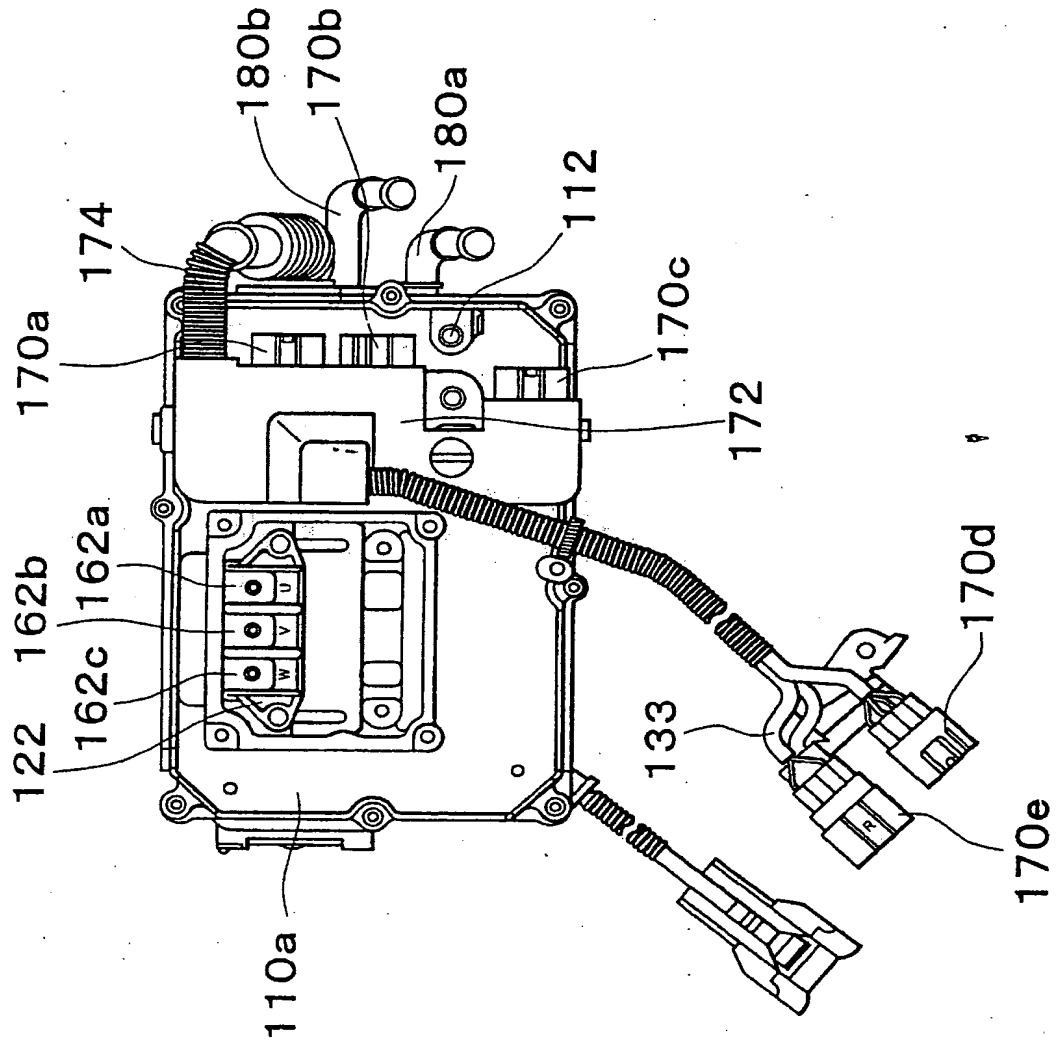


FIG. 5

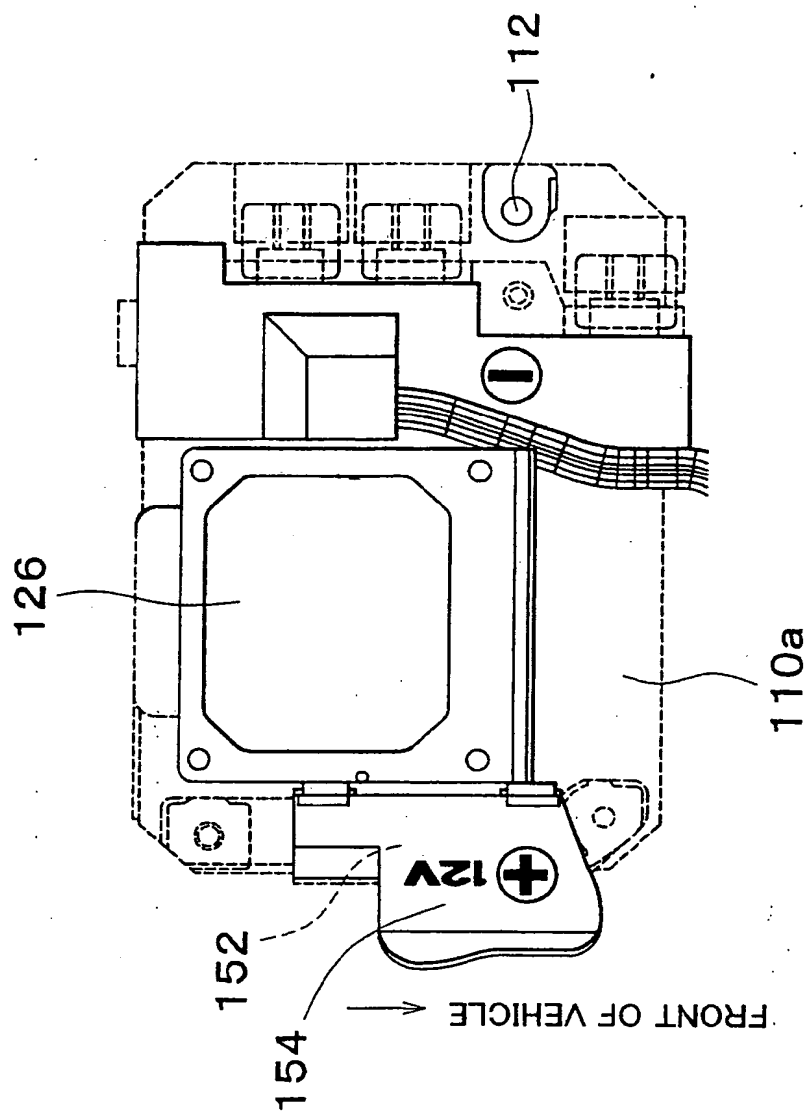


FIG. 6

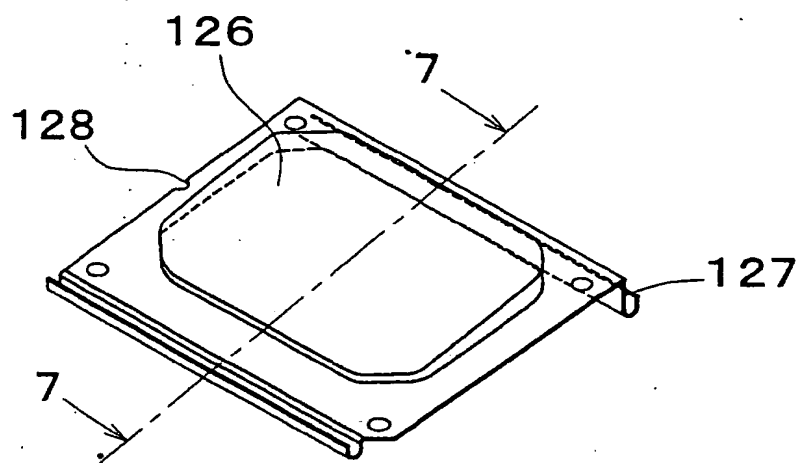
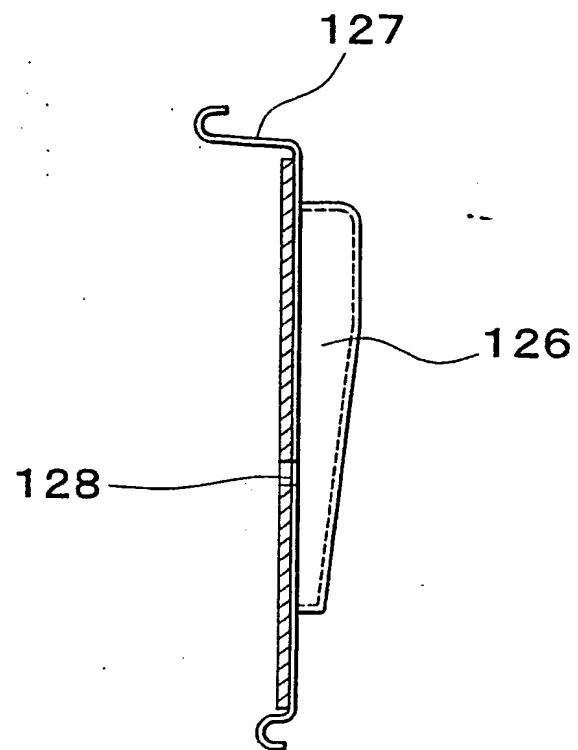


FIG. 7



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